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IS 14571 (1998): Electrical measuring instruments - X-Y recorders [ETD 12: Measuring Equipment for Basic Electrical Quantities]

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भारतीय मानक

विद्युत मापन यंत्र — X-Y रिकार्डर

Indian Standard

ELECTRICAL MEASURING INSTRUMENTS — X-Y RECORDERS

ICS 19.080; 17.220.20

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

July 1998 **Price Group 11**

Measuring Equipment for Basic Electrical Quantities Sectional Committee, ETD 12

NATIONAL FOREWORD

This Indian Standard which is identical with IEC 1028 (1991) 'Electrical measuring instruments — X-Y recorders' issued by the International Electrotechnical Commission (IEC) was adopted by the Bureau of Indian Standards on the recommendation of the Measuring Equipment for Basic Electrical Quantities Sectional Committee (ETD 12) and approval of the Electrotechnical Division Council.

This standard applies to X-Y recorders used for recording analogue electrical signals.

In this Indian Standard the following International Standards are referred to. Read in their respective places the following:

International Standard	*Indian Standard*	*Degree of Equivalence*
IEC 68 Environmental testing	IS 9000 (Part 1) : 1988 Basic environmental testing procedures for electronic and electrical items : Part 1 General (*first revision*)	Equivalent
IEC 160 (1963) Standard atmospheric conditions for test purposes	IS 9676 : 1980 Reference ambient temperature for electrical equipment	do

Certain conventions appearing in this dual number standard are not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Wherever the words 'International Standard' appear, referring to this standard, they should be read as 'Indian Standard'.

b) Comma (,) has been used as a decimal marker while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Amendment 1 to the above International Standard has been printed at the end.

Only the English language text in the IEC standard has been retained while adopting it in this Indian Standard.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

ELECTRICAL MEASURING INSTRUMENTS — X-Y RECORDERS

1. Scope

This standard applies to X-Y recorders used for recording analogue electrical signals.

This standard specifies requirements for X-Y recorders, which can be used for the measurement of:

- a voltage or a current;
- another electrical quantity;
- a non-electrical quantity.

Recorders for measuring quantities other than voltage or current may contain a device for converting the input quantity into a voltage or current. If the conversion device is interchangeable and removable, this standard applies only to the recorder, provided that the conversion function is known.

This standard applies to recorders and their accessories having electronic devices in their measuring and/or auxiliary circuit(s).

It also applies to non-interchangeable accessories and accessories of limited interchangeability (e.g. shunts, impedance elements, etc.) when they are used with the recorder and adjustments have been made for the combination.

This standard does not apply to X-t recorders: For X-Y recorders incorporating a time base, this standard applies to the X-Y function only.

This standard does not apply to special purpose recorders which are covered by their own IEC standards.

This standard does not apply to special purpose devices nor to interchangeable accessories which are covered by their own IEC standards when they are used as accessories.

For controllers with electrical outputs, containing electrical recorders this standard applies only to the recorder and does not apply to the control circuit.

This standard does not contain requirements for protection against environmental conditions or the relevant tests. If information is required on these aspects, reference should be made to IEC Publication 68.

This standard does not cover safety requirements. For further information, reference should be made to IEC Publication 1010.

2. Definitions

The values of a.c. quantities given in this standard are r.m.s. values, unless otherwise stated.

For the purpose of this standard the following definitions apply.

2.1 *General terms*

2.1.1 *Recorder*

A measuring instrument which records, on a recording medium, information corresponding to the values of the measurand.

Notes 1. – Some recorders may incorporate an indicating device.

2. – Some recorders may record information corresponding to more than one measurand.

3. – Some recorders may also include interchangeable plug-in units. In this case, the recorder may have different specifications depending on the plug-in unit being used.

2.1.2 *X-Y recorder*

A recorder which traces the relationship between two or more analogue electrical signals as a continuous line on two perpendicular axes of a chart.

2.1.3 *Accessory*

An element, group of elements or device associated with the measuring circuit of a recorder in order to confer specified characteristics on the recorder.

2.1.3.1 *Interchangeable accessory*

An accessory having its own properties, class index or accuracy class these being independent of those of the recorder with which it may be associated.

Note. – An accessory is considered to be interchangeable when its rated characteristics are known, marked and sufficient to enable its errors and variations to be determined without using the associated recorder. For example, a shunt, whose adjustment takes into account an instrument current which is not negligible and which is known, is considered to be interchangeable.

2.1.3.2 *Accessory of limited interchangeability*

An accessory having its own properties and errors which can only be associated with recorders for which certain characteristics are within specified limits.

2.1.3.3 *Non-interchangeable accessory*

An accessory adjusted to take into account the electrical characteristics of a specific recorder.

2.1.4 *Distortion factor* (total harmonic distortion factor of a quantity)

$$\text{The ratio } \frac{\text{r.m.s. value of the harmonic content}}{\text{r.m.s. value of the non-sinusoidal quantity}}$$

2.1.5 *Ripple factor*

$$\text{The ratio } \frac{\text{r.m.s. value of the fluctuating component}}{\text{value of the d.c. component}}$$

2.2 *Description of recorders according to the number of recording devices*

2.2.1 *Single recorder*

A recorder having one recording device.

2.2.2 *Multiple recorder*

A recorder having more than one recording device and being able to record, simultaneously, different quantities corresponding to different external signals.

2.2.3 *Single-range recorder*

A recorder having only one measuring range.

2.2.4 *Multi-range recorder*

A recorder having more than one measuring range.

2.3 *Description of recorders according to their method of marking*

2.3.1 *Pen recorder*

A recording instrument in which the record on the chart is made by a pen supplied with ink. (IEV 302-02-11.)

2.3.2 *Stylus recorder*

A recording instrument in which the record on the chart is made by a stylus requiring no ink. (IEV 302-02-12.)

2.4 *Constructional features*

2.4.1 *Measuring circuit* (of a recorder)

The part of the electrical circuit internal to the recorder and its accessories, together with the interconnecting leads, if any, which is energized by a voltage or a current, one or both of these quantities being a prime factor in determining the recording of the measurand (one of these quantities may be the recorded quantity itself).

2.4.1.1 *Current circuit*

A measuring circuit through which flows a current which is the prime factor in determining the recording of the measurand.

Note. – This may be the current directly involved in the recording or a proportional current supplied by an external current transformer or derived from an external shunt.

2.4.1.2 *Voltage circuit*

A measuring circuit to which is applied a voltage which is the prime factor in determining the recording of the measurand.

Note. – This may be the voltage directly involved in the recording or a proportional voltage supplied by an external voltage transformer or an external voltage divider, or derived by means of an external series resistor (impedance element).

2.4.2 *External measuring circuit*

The part of the electrical circuit external to the recorder from which a measured value is obtained.

2.4.3 *Auxiliary circuit*

A circuit, other than the measuring circuit, required for the operation of the recorder.

2.4.4 *Auxiliary supply*

An auxiliary circuit providing electrical energy.

2.4.5 *Measuring element*

The assembly of those parts of a recorder which are acted upon by a measurand, resulting in a movement of the moving element related to that quantity.

2.4.5.1 *Indirect acting measuring element*

The active part of a recorder which includes those parts whose interaction controls the servo-mechanism.

2.4.5.2 *Servo-mechanism*

An automatic control system in which the controlled variable is the mechanical position of the recording device.

Note. – The action of the servo-mechanism is a function of the measurand and of the position of the recording device.

2.4.6 *Indicating device*

The set of components which displays the value of a measurand or a related value.

2.4.7 *Index*

The fixed or movable part of an indicating device whose position with reference to the scale marks enables an indicated value to be determined.

2.4.8 *Scale*

An ordered set of scale marks, together with any associated numbering, forming a part of an indicating device.

2.4.9 *Recording device*

The set of components which records the value of a measurand or a related value.

Note. – According to the method and kind of marking, it may comprise

- a pen associated with an ink supply, or
- a stylus.

2.4.10 *Zero and zero adjuster*

2.4.10.1 *Zero (Electrical zero)*

The record of a recorder when it is in use and with zero value of the measurand.

2.4.10.2 *Zero scale mark*

The mark on the scale or chart associated with the figure zero.

2.4.10.3 *Zero adjuster*

The device by means of which the recorder may be adjusted so that the zero (lower/upper limit of the measuring range) coincides with the appropriate scale mark.

2.4.10.4 *Recorder with zero displacement*

A recorder which employs an additional device to change the position of the zero.

2.4.10.5 *Zero displacement value*

For a recorder with zero displacement, the value of the measurand expressed as a percentage of the effective range (span), which corresponds to the difference between the indicated or recorded values with and without the zero displacement, for the same value of the measurand.

2.4.11 *Span vernier*

A device which allows continuous fine adjustment of the sensitivity.

2.4.12 *Record on/off control*

A device by means of which the record may be enabled/disabled without interrupting the function of the servo-mechanism.

2.4.13 *Servo-release mechanism*

The mechanism used to separate the recording device (e.g. pen) from the (pen drive) servo, to allow it to be moved freely by hand.

2.4.14 *Chart*

A strip or sheet provided with or without chart lines and with or without numbering, from which are obtained the values of the measurands, possibly by means of a reading rule.

2.4.15 *Record*

The line(s) made on the chart by the recording device of the recorder.

2.4.16 *Chart lines*

The series of pre-printed lines on the chart which enable the record to be interpreted.

2.4.17 *Chart division*

The interval between two adjacent chart lines.

2.4.18 *Chart line numbering*

The series of numbers designating the chart lines.

2.4.19 *Chart scale length*

The length of the path traversed by the recording device between the extreme chart scale lines, when the recording device is moved in the direction of one of the two axes.

2.5 *Characteristic features*

2.5.1 *Span*

The algebraic difference between the upper and lower limits of the measuring range. It is expressed in units of the measurand.
Example: Measuring range −10 V ... +10 V; span = 20 V.

2.5.2 *Measuring range*

The set of values of a measurand within which the limits of error of a recorder are specified.

Note. – A recorder and/or its accessory can have several measuring ranges.

2.5.3 *Overshoot*

The difference between the extreme recorded value and the steady recorded value when the measurand is abruptly changed from one constant value to another by a specified amount.

2.5.4 *Dynamic performance*

All the data which characterize the performance of a recorder when the measurand varies.

2.5.4.1 *Response time*

The time interval between the instant when a stimulus is subjected to a specified abrupt change and the instant when the response reaches and remains within specified limits of its final steady value.

2.5.4.2 *Frequency response range*

The range of frequencies of a sinusoidally varying measurand to which the recorder will respond within specified limits relating to amplitude.

2.5.4.3 *Phase difference response range*

The range of frequencies of a sinusoidal measurand applied to both axes simultanously to which the recorder will respond within specified limits relating to phase difference.

2.5.4.4 *Maximum acceleration*

Maximum value of acceleration of the recording device when it responds to a step input on one axis.

2.5.4.5 *Slewing speed*

Maximum speed which the recording device reaches when it is moved along one of the axes.

2.5.4.6 *Sensitivity*

The change in the response of a recorder divided by the corresponding change in the input quantity.

Note. – The reciprocal of this is commonly used (measurand divided by response).

2.5.4.7 *Dead band*

The range through which a measurand may be varied without producing a change in the record.

2.5.5 *Impedance of the external measuring circuit (source impedance)*

The impedance of the external measuring circuit as seen from the input terminals of the recorder.

2.5.6 *Impedance of the internal measuring circuit (input impedance)*

The impedance of the internal measuring circuit as seen from the input terminals of the recorder.

2.5.7 *Parasitic voltages*

2.5.7.1 *Common mode voltage (between measuring circuit and earth)*

That part of the input voltages, for which the amplitude and either the phase or the polarity are the same, which exists between each of the input terminals and a reference point.

Note. – This reference point may be the frame terminal or the measuring earth terminal, or it may be an inaccessible point.

2.5.7.2 *Series mode voltage (series voltage)*

An unwanted part of the input voltage which is superimposed on the voltage initiated by the measurand.

Note. – Typical examples of a series mode voltage are induced voltages, an a.c. ripple on a d.c. signal, or thermopotentials.

2.6 *Characteristic values*

2.6.1 *Nominal value*

A value of a quantity indicating the intended use of a recorder or an accessory.

Notes 1. – The intended characteristics of recorders and accessories are also nominal values.

2. – The nominal value may be a rounded value of the characteristic concerned and is often an appropriate value of the quantity reproduced by a measurement standard.

2.6.2 *Rated value*

A value of a quantity assigned, generally by the manufacturer, for a set of specified operating conditions.

2.6.3 *Fiducial value*

A clearly specified value of a quantity to which the error(s) of a recorder and/or an accessory are referred in order to specify their respective accuracies.

Note. – This value can, for example, be the upper limit of the measuring range, the span or another clearly stated value.

2.7 *Influence quantity, reference conditions, nominal range of use and preconditioning*

2.7.1 *Influence quantity*

A quantity which is not the subject of the measurement but which influences the value of the record.

For example: humidity, ambient temperature, frequency of a measured voltage.

2.7.2 *Reference conditions*

Conditions of use for a recorder prescribed for performance testing, or to ensure valid comparison of results of measurements.

Note. – Reference conditions generally specify reference values or reference ranges for the influence quantities affecting the recorder.

2.7.2.1 *Reference value*

A specified value of one of a set of reference conditions.

2.7.2.2 *Reference range*

A specified range of values of one of a set of reference conditions.

2.7.3 *Nominal range of use*

A specified range of values which an influence quantity may assume without causing a variation exceeding specified limits.

2.7.4 *Limiting values of an influence quantity*

Extreme values which an influence quantity can assume without the recorder or accessory being damaged or permanently altered in such a way that it no longer meets the requirements of its accuracy class.

Note. – The limiting values may depend on the duration of their application.

2.7.5 *Preconditioning*

The action whereby, under reference conditions, a specified value of the measurand is applied to the measuring circuit prior to carrying out testing or use of the recorder or accessory.

2.7.6 *Preliminary adjustments*

Adjustments, specified by the manufacturer, that must be made before using the recorder so that it will operate with specified accuracy.

2.8 *Errors and variations*

Note. – The concept of error is limited to those errors determined when the recorder is under reference conditions. This concept of error is concerned with the intrinsic qualities of the recorder in contradistinction to the variation in the record which may arise from the use of the recorder under conditions other than the reference conditions.

2.8.1 *Absolute error*

For a recorder, the value obtained by subtracting the conventional true value from the recorded value.

For an accessory, the value obtained by subtracting the conventional true value from the rated value.

Notes 1. – Since the true value cannot be obtained by measurement, a value obtained under specified test conditions and at a specified time is used instead. This value is derived from national measurement standards or reference measurement standards agreed upon by manufacturer and user.

2. – "Absolute error", which has a sign, should not be confused with "absolute value of an error" which is the modulus of an error.

3. – When a recorder is used together with an accessory, the error of such a combination is calculated by taking the algebraic sum of the errors of the recorder and the accessory.

4. – In practice, the error of measurement can only be determined with some uncertainty.

2.8.2 *Intrinsic error*

The error of a recorder and/or its accessory when under reference conditions.

2.8.3 *Variation*

The difference between the two recorded values for the same value of the measurand when a single influence quantity assumes successively two different specified values within the nominal range of use.

2.8.3.1 *Additional error term due to zero displacement expressed as a percentage of the zero displacement*

One hundred times the difference between the specified value and the measured value of the displacement, divided by the specified value of the displacement.

2.8.3.2 *Errors (variations) expressed as a percentage of the fiducial value*

One hundred times the ratio of the absolute error (variation) to the fiducial value.

2.9 *Accuracy, accuracy class and class index*

2.9.1 *Accuracy*

The ability of a recorder to provide a record approaching the conventional true value of a measurand.

For an accessory, the closeness of the rated value to the conventional true value.

Note. – The accuracy of a recorder or of an accessory is defined by the limits of intrinsic error and by the limits of variations.

2.9.2 *Accuracy class*

A group of recorders and/or accessories which meets certain metrological requirements intended to keep errors and variations within specified limits.

Note. – An accuracy class shall be indicated for each axis.

2.9.3 *Class index*

The number which designates the accuracy class.

Note. – Some recorders and/or accessories may have more than one class index.

3. Classification and compliance

3.1 *Class index*

Recorders satisfying this Standard are classified according to their accuracy class related to the measurand for each of the axes.

Accuracy class indices shall be selected from a 1 – 1.5 – 2 – 2.5 – 3 – 5 sequence or their decimal submultiples.

3.2 *Compliance with the requirements of this Standard*

Recorders and accessories shall comply with the relevant requirements of this standard relating to their accuracy class or class indices.

If, for the determination of intrinsic errors and variations, preconditioning is specified, the manufacturer shall state the preconditioning period and all other relevant conditions.

Recorders and their accessories shall be adequately packed to ensure that, after transport under normal conditions, they comply with the requirements of this standard.

4. Reference conditions and intrinsic errors

4.1 *Reference conditions*

The recorder shall be put into operation according to the specifications of the manufacturer.

The reference conditions of the influence quantities shall be as given in Table I unless otherwise stated.

The reference value for the ambient temperature shall be specified by the manufacturer and shall be selected from 20 °C, 23 °C or 27 °C in accordance with IEC Publication 160.

Reference conditions different from those given in Table I may be specified.

4.2 *Fiducial value and limits of intrinsic errors*

When the recorder, together with its non-interchangeable accessory(ies) (if any), is under the reference conditions given in Table I and is used between the limits of its measuring range and in accordance with the manufacturer's instructions, the intrinsic error, expressed as a percentage of the fiducial value, shall not exceed the limits appropriate to its accuracy class. Values stated in a table of corrections supplied with the recorder shall not be taken into account in determining the errors.

Notes 1. – The intrinsic error includes other error components such as those due to dead band, amplifier drift, etc.

2. – However, for multi-range recorders, the manufacturer may, in addition to the class index, state a value of the maximum absolute error (expressed e.g. in microvolts).

4.2.1 *Correspondence between intrinsic error and accuracy class*

The maximum permissible error is related to the accuracy class such that the class index is used as the limit of error, expressed as a percentage with positive and negative signs.

Note. – For example, for a class index of 0.05, the limits of intrinsic error are ± 0.05% of the fiducial value.

4.2.2 The fiducial value for the measurand corresponds to the span. For zero displacement, the fiducial value corresponds to the nominal value of zero displacement.

TABLE I – Reference conditions and tolerances for testing purposes relating to the influence quantities

Influencing quantity		Reference conditions unless otherwise stated	Tolerances permitted for testing purposes, applicable for a single reference value
Ambient temperature		See Sub-clause 4.1	± 2 °C
Relative humidity		40% to 60%	-
Position		Supporting plane horizontal	± 5°
Ripple of d.c. measurand		Zero	1%
Distortion of a.c. measurand		Distortion factor to be stated by the manufacturer	
Frequency of a.c. measurand		To be stated by the manufacturer	± 1%
Magnetic field of external origin		Total absence	40 A/m* at frequencies from zero to 65 Hz in any direction
Electric field of external origin		Total absence	1 kV/m at frequencies from zero to 65 Hz in any direction
Auxiliary supply	Voltage	Nominal value or nominal range to be stated by manufacturer	± 1% of nominal value
	Frequency	Nominal value or nominal range to be stated by manufacturer	± 1% of nominal value
Parasitic voltages	Series mode voltage, a.c. or d.c.	Zero	1% of the values indicated in Table II for the nominal range of use
	Common mode voltage, a.c. or d.c.	Zero	
Impedance of external measuring circuits		To be stated by the manufacturer	
Chart		To be stated by the manufacturer	
Recording device (recording means)		To be stated by the manufacturer	

* 40 A/m is approximately the highest value of the earth's magnetic field.

Note.– These tolerances apply when a single reference value is specified in this table or is marked by the manufacturer. For a reference range, no tolerance is allowed.

TABLE II – Limits of the nominal range of use and permissible variations

Influence quantity		Limits of the nominal range of use unless otherwise stated	Permissible variation expressed as a percentage of the class index
Ambient temperature		Reference temperature ± 10 °C	100
Relative humidity		25% and 75%	100
Position		± 10° from the reference position (or reference range if any)	100
Ripple of d.c. measurand		To be stated by the manufacturer	
Distortion of a.c. measurand		To be stated by the manufacturer	
Frequency of a.c. measurand		To be stated by the manufacturer	
Magnetic field of external origin		See Sub-clause 5.2.1	100
Auxiliary supply	Voltage	Reference value ± 10% or lower limit of reference range -10% and upper limit of reference range +10%	50
	Frequency	Reference value ± 5% or lower limit of reference range -5% and upper limit of reference range +5%	50
Parasitic voltage	Series mode voltage, a.c. or d.c.	To be stated by the manufacturer	100
	Common mode voltage, a.c. or d.c.		
Impedance of external measuring circuits		To be stated by the manufacturer	100

4.3 *Conditions for the determination of intrinsic error*

The preconditioning period should normally be 30 min and should not be more than 2 h for convenience.

The errors shall be determined for increasing and decreasing values of the measurand. All the values of the errors shall be within the limits specified.

The recorded value of the measurand is read from the chart. If the value is read from chart lines, an appropriate correction shall be made to take account of the accuracy of the distances of the chart lines.

The determination of intrinsic error shall be carried out as follows:

a) Single-range recorder

The measurand shall be applied to the recorder under test and to a reference instrument and progressively changed in such a way as to avoid overshoot until the required value is reached on the reference instrument. The test is carried out for each axis separately.

Note. – This method was chosen because it takes better account of automatic calibrators which are preferred for recorder testing.

b) Multi-range recorder

The determination of errors shall be carried out in the same manner as for single-range recorders but by using first one of the ranges and then, successively, the others, including repeated preconditioning where specified.

Note. – The reason for this repeated preconditioning is that the total impedance of the circuit may vary when changing the measuring range and, in consequence, the offset voltage compensation of an input amplifier may change.

4.4 *Determination of the value of the dead band*

The following method is recommended in order to determine the dead band at a given point in the measuring range.

The starting point corresponds to a value of the measurand smaller than the chosen value by an amount equivalent to five times the class index. The measurand is slowly increased until the chosen value is read on the reference instrument and the recorded value is then noted. The same operations are then repeated, starting at a value greater than the chosen value by an amount equivalent to at least five times the class index and decreasing the measurand. The difference between the two values noted is the value of the dead band (see explanatory note to 4.3 *a)*).

4.4.1 *Limits of the dead band*

Under reference conditions the dead band is included within the intrinsic error. The dead band shall not exceed the value corresponding to the class index when any one of the influence quantities is within its nominal range of use. Only a lower value of the dead band may be specified by the manufacturer.

4.5 *Additional error term due to zero displacement*

The limits of the additional error shall have a value not exceeding 100% of the class index. Only a lower value may be specified by the manufacturer.

4.6 *Orthogonality error*

This test is carried out by recording straight lines for each axis independently on the same chart over the full scale length, and by measuring the maximum gap between the Y-axis trace and a datum line which intersects the X-axis precisely at right angles. The gap (error) expressed as a percentage of the scale length shall be within the value specified by the manufacturer.

5. Nominal range of use and variations

5.1 *Nominal range of use*

5.1.1 The limits of the nominal range of use for influence quantities shall be as given in Table II.

5.1.2 When a manufacturer specifies a nominal range of use which is different from that shown in Table II, the range shall include the reference range (or reference value with permitted tolerances) and normally exceed it in at least one direction.

5.1.2.1 For values of the nominal range of use beyond the reference range (or reference value), the variation should not exceed the values given in Table II.

5.1.2.2 When an influence quantity is not one of those shown in Table II, the value of the influence quantity and the resultant variation shall be stated by the manufacturer. The variation shall not exceed 100% of the class index.

5.1.2.3 *Mutual influence between the different circuits of a multiple recorder*

The variation arising from a mutual influence between the different measuring circuits is determined by energizing one measuring circuit so that a deflection equal to ⅔ of the scale length corresponding to the measuring range is obtained and by changing the measurand of each of the other measuring circuits between the limits of their measuring range under the most unfavourable phase or polarity conditions. The variation of the first measuring circuit is recorded. The test is repeated, in turn, on every measuring circuit.

The variation shall not exceed 50% of the class index.

5.2 *Limits of variations*

When a recorder or an accessory is under reference conditions and a single influence quantity is varied, the variation shall not exceed the values given in Table II and in Sub-clauses 5.1.2.2 and 5.1.2.3. The variation includes the thickening of the trace.

5.2.1 *Variation due to a magnetic field of external origin*

5.2.1.1 When a recorder is not marked with Symbol F-30 (Table IV) and no relevant information is given in the documentation, the magnetic field strength shall be 0.4 kA/m at mains frequency.

5.2.1.2 For recorders marked with Symbol F-30 (Table IV), or with relevant information in the documentation, the magnetic field strength at mains frequency shall have a value, expressed in kiloamperes per metre (kA/m), as given in the symbol or documentation.

5.2.1.3 The test procedure is as follows:

The test for variation due to a magnetic field of external origin is carried out using all orientations of the magnetic field and using alternating current at the mains supply frequency to produce the magnetic field.

The field should be produced by a coil having a mean diameter not less than 4 times the maximum dimension of the recorder. The current shall be such as to produce a magnetic field of 0.4 kA/m in the centre of the coil in the absence of the recorder to be tested.

Under the conditions of Sub-clauses 5.2.1.1 and 5.2.1.2, the variation shall not exceed the limits given in Table II. The test shall be carried out for each axis separately under the most unfavourable conditions.

5.2.2 *Variation due to parasitic voltages*

Note. – The influence of parasitic voltages shall be determined by the methods given in Appendix A.

5.2.2.1 The manufacturer shall state the values of the parasitic voltages for which the variation does not exceed a value corresponding to 100% of the class index. Parasitic voltages may be limited by safety requirements.

The influence of parasitic voltages shall be stated for:

- common mode interference;
- series mode interference.

5.2.2.2 The common mode test is made with a direct voltage and with an alternating voltage at mains frequency.

The series mode test for recorders measuring d.c. quantities is made with an a.c. voltage having a frequency equal to the mains frequency and also to twice this value.

The alternating parasitic voltages shall be derived from the mains supply to the recorder. The phase relationship between the mains voltage and the parasitic voltages shall be so adjusted as to obtain the maximum influence. For recorders measuring a.c. quantities, the series mode voltage is a d.c. voltage.

The manufacturer may state the interference for any other frequency of parasitic voltage.

5.2.2.3 The earthing (grounding) conditions, including connections with the internal screen, if any, shall be those stated by the manufacturer. If there is no earth terminal, the manufacturer shall state which conductive part of the recorder may be used as an earthing (grounding) point.

5.3 *Conditions for the determination of variations*

5.3.1 The variations shall be determined for each influence quantity shown in Table II.

5.3.2 For preconditioning see Sub-clause 4.3.

5.3.3 The variations shall be determined for each influence quantity and for each axis separately.

During each test all influence quantities shall be maintained at their reference conditions except for the influence quantity for which the variation is to be determined.

5.3.3.1 When a reference value is given, the influence quantity shall be varied between that value and any value within the limits of the nominal range of use as given in Table II unless otherwise specified.

5.3.3.2 When an influence quantity has a reference range, it shall be varied from each limit of the reference range to the adjacent limit of the nominal range of use.

5.3.3.3 The determination of variations associated with the influence quantities shall be made between 40% and 60% of the span.

6. Further electrical and mechanical requirements

6.1 *Dynamic performance*

The recorder shall be under reference conditions, the auxiliary circuits being energized. The impedance of the external measuring circuit shall have a steady value between the limits stated by the manufacturer. The amplifier gain or the attenuation, if any, shall be set as specified by the manufacturer.

6.1.1 *Response time*

Sudden changes in the input quantity corresponding to a steady deflection of 10% and 95% of the span shall be applied. The times required for the recording device to settle at its final position within a percentage of the span equal to the class index shall not exceed the value stated by the manufacturer. The response time shall be measured in both directions and for both axes. In addition, other values may be stated by the manufacturer.

6.1.2 *Frequency response*

The test is carried out by applying successively two sinusoidal input quantities, the values of which correspond to a peak-to-peak deflection of ⅔ and ⅒ of the span respectively.

The values of frequency at which the deflection reduces to 90% of its d.c.-(low-frequency-)deflection shall be equal to or greater than the values stated by the manufacturer.

6.1.3 *Phase difference response*

The test is carried out by applying simultaneously to both axes a sinusoidal input quantity, the value of which corresponds to a peak-to-peak deflection of ⅔ of the shorter axis.

The frequency values at which the distance between the ascending and descending record differ by not more than the value corresponding to the class index shall be equal to, or greater than, the value stated by the manufacturer. The distance shall be measured at right angles to the peak-to-peak axis of the record.

6.1.4 *Overshoot*

The overshoot shall be measured by carrying out the tests corresponding to Sub-clause 6.1.1. In no case shall the overshoot exceed a value corresponding to twice the class index. The manufacturer may state a lower value.

6.1.5 *Acceleration and pen slewing speed*

The values of acceleration and pen slewing speed measured successively for the *X*- and *Y*-axes at the recording device shall be equal to, or greater than, the values stated by the manufacturer. It is not mandatory that the values be stated but, if stated, the manufacturer shall indicate an adequate measuring method.

6.1.6 *Prescription of record-on and record-off delay times*

6.1.6.1 For recorders where the record on/off control is externally controllable, the maximum values of the record-on and record-off delay times shall be specified by the manufacturer.

6.1.6.2 *Test method* (see Figure 1)

An input quantity having a known triangular wave-form shall be applied to the input terminals of the *X*-axis to provide a known time scale in the *X* direction. This wave-form shall have a frequency appropriate to the expected delay times.

An input quantity having a value Y_1 (which may be zero) shall be applied to the input terminals of the *Y*-axis and shall be suddenly increased to the value Y_2 and then back again to Y_1

A record of this procedure shall be made.

The above procedure shall then be repeated but, this time, the record on/off control shall be triggered by both changes of the *Y*-axis signal.

The record-on and record-off delay times can be determined by graphical means.

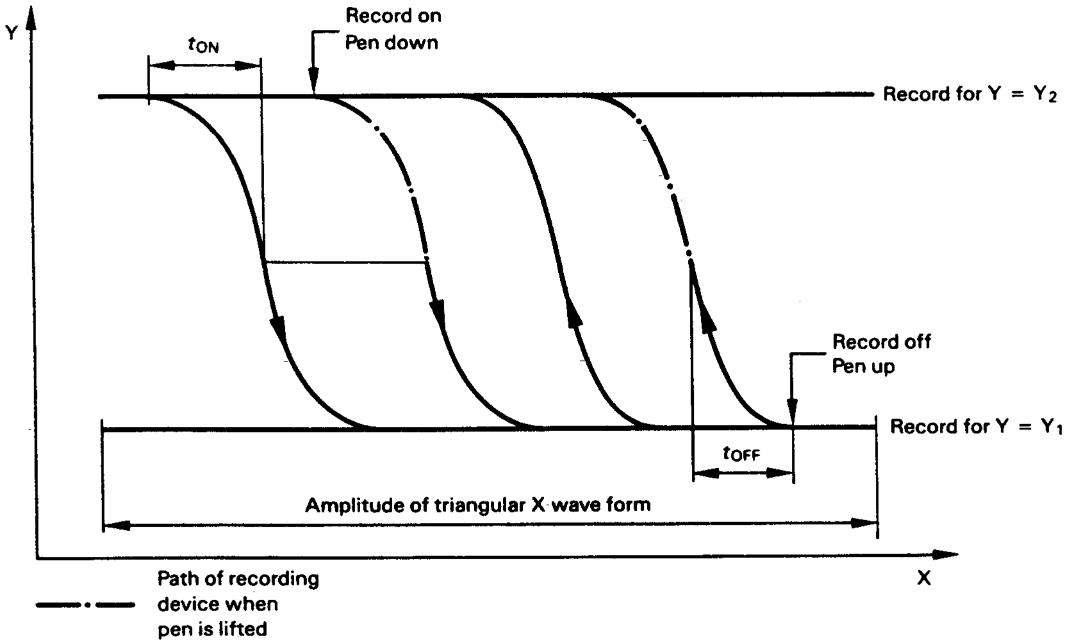

Figure 1 – Determination of record-on and record-off delay times

6.2 *Continuous load*

Recorders, together with their accessories (if any), shall comply with the requirements corresponding to their accuracy class after being continuously operated under reference conditions.

Note. – For convenience, a test period of six hours is considered to be sufficient.

6.3 *Permissible overloads*

The following conditions for applying overloads are only valid for the measuring system and not for the auxiliary supply.

The overload tests shall be carried out under reference conditions.

6.3.1 *Continuous overload*

Recorders, together with their non-interchangeable accessories (if any), shall be subjected to a continuous overload of 120% of the upper limit of each measuring range for a period of 2 h.

After returning to the reference temperature, the recorders, together with their non-interchangeable accessories (if any), shall comply with the accuracy requirements.

6.3.2 *Overload of short duration*

Recorders, together with their non-interchangeable accessories (if any), shall withstand, without damage, an input quantity corresponding to 200% of the upper limit of each measuring range for a period of 10 s. Only higher values for the input quantity and/or the time may be stated by the manufacturer.

The only permissible exceptions are those due to safety requirements.

After returning to reference temperature and after the preliminary adjustment procedures have been repeated, the recorders together with their non-interchangeable accessories (if any), shall comply with the accuracy requirements.

6.4 *Limiting values of temperature*

Unless otherwise specified, recorders and/or their accessories shall operate without incurring permanent damage when subjected to ambient temperatures between 0 °C and 40 °C. For convenience, a test period of 6 h at each temperature limit is considered to be sufficient.

Absence of permanent damage is inferred if, on return to reference conditions, the recorders and/or their accessories comply with the requirements relating to intrinsic error. Adjustment of the zero is permissible.

7. **Constructional requirements**

7.1 *Sealing to prevent access*

When the recorder is sealed to prevent unauthorized adjustment, access to the internal circuits and to the components within the case shall not be possible without destroying the seal.

7.2 *Preferred values for sensitivity*

The sensitivities of the recorder should preferably be specified in the form:

measurand/millimetre
and be selected from a 1-2-5 sequence or decimal multiples or submultiples thereof.

8. Information, markings and symbols

If applicable, the markings or symbols given in Table IV should be used. The markings, if any, shall be indelible and remain legible under normal conditions of use.

8.1 *Information on the recorder*

The following information shall appear on all recorders and/or their accessories:

a) manufacturer's name or mark;

b) designation of the type of recorder;

c) serial number or reference number;

*d)** nature of the measurand;

e) nature and rated value(s) of the auxiliary supply (supplies);

*f)** rated value(s) of the measuring range(s);

g) symbol showing that some essential information is given in a separate document if relevant (Symbol F-33);

h) necessary data for using and testing the recorder if the marking on the scale or chart does not coincide with the measurand. If the data cannot be marked sufficiently clearly on the recorder, Symbol F-33 shall be used;

i) maximum permissible value of voltage to earth (ground).

8.2 *Information in documentation*

All information, including identification of terminals and means of earthing necessary for correct operation, storage and transport of the recorder, together with its accessories (if any), and to prove compliance with this standard and compliance with the relevant safety requirements (see C Symbols, Table IV), shall be provided on the recorder or in the accompanying documentation.

8.3 *Information relating to reference conditions and nominal ranges of use*

8.3.1 Reference values or reference ranges, as well as nominal ranges of use corresponding to each influence quantity, shall be indicated.

8.3.2 When any limit of the nominal range of use is the same as the reference value or the adjacent limit of the reference range, the number indicating the reference value or the limit of the reference range shall be repeated for the limit of the nominal range of use.

8.3.3 If a reference value or reference range is marked, it shall be identified by underlining.

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* This information need not be indelible and may be shown, for example, on a display.

8.3.4 The influence quantity shall be identified by the symbol of its unit.

8.3.5 Table III shows the significance of the various markings for temperature.

TABLE III – Examples of marking of reference value/range and nominal range of use for temperature

Example	Meaning
25 °C	Reference value: 25 °C Nominal range of use: 15 °C to 35 °C
20...*25*...30 °C	Reference value: 25 °C Nominal range of use: 20 °C to 30 °C
15 ...*20...25*...30 °C	Reference range: 20 °C to 25 °C Nominal range of use: 15 °C to 30 °C (Permissible variations from 15 °C to 20 °C and from 25 °C to 30 °C)
20 ...*20...25*...30 °C	Reference range: 20 °C to 25 °C Nominal range of use: 20 °C to 30 °C (Permissible variation from 25 °C to 30 °C)

TABLE IV – Symbols for marking recorders and their accessories

Symbols for units ot measurement and their prefixes are given in IEC Publication 27. For convenience, the symbols most likely to be needed for marking recorders and their accessories and a list of the SI prefixes are given below.

IV A – Units	
Item	**Symbol**
ampere	A
decibel	dB
degree Celsius	°C
hertz	Hz
metre	m
ohm	Ω
power factor	cos Φ or cos φ
second	s (lower case)
siemens	S (upper case)
tesla	T
volt	V (upper case)
voltampere	VA (upper case)
voltampere reactive	var (lower case)
watt	W (upper case)

SI prefixes		
Item		**Symbol**
exa	10^{18}	E
peta	10^{15}	P
tera	10^{12}	T
giga	10^{9}	G
mega	10^{6}	M (upper case)
kilo	10^{3}	k (lower case)
hecto[1]	10^{2}	h (lower case)
deca[1]	10	da (lower case)
deci[1]	10^{-1}	d (lower case)
centi	10^{-2}	c (lower case)
milli	10^{-3}	m (lower case)
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a

[1] These items are non-preferred and their use should be avoided.

(Table continued on page 23)

The symbol of a prefix (if needed) immediately precedes, without a space, the symbol of a unit.

If there is a number, it is followed by a space before the prefix (if any) and the unit (e.g. 23 °C, 120 mV).

TABLE IV *(continued)*

IV B – Nature of measurand		
No.	Item	Symbol
B-1	Direct current circuit and/or d.c. responding measuring element	⎓ (5031)*
B-2	Alternating current circuit and/or a.c. responding measuring element	∼ (5032)*
B-3	Direct and/or alternating current circuit and/or d.c. and a.c. responding measuring element	≂ (5033)*

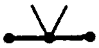
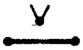
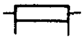
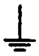
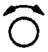
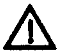
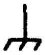
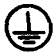
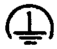
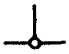
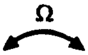
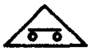
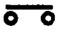
IV C – Safety (for application, see IEC Publication 1010)		
No.	Item	Symbol
C-1	Test voltage 500 V	☆ (5179)*
C-2	Test voltage above 500 V (e.g. 2 kV)	☆2
C-3	Apparatus not subjected to a voltage test	☆0
C-4	Dangerous voltage	ϟ (5036)*
C-7	High voltage on accessory and/or on instrument (e.g. voltmeter)	ϟⓋ

* Numbers identified by an asterisk are the reference numbers of the symbols in IEC Publication 417. The number is not a part of the symbol.

IV E – Accuracy class		
No.	Item	Symbol
E-10	Class index (e.g. 1) when the fiducial value corresponds to the span	| 1 |

(Table continued on page 24)

TABLE IV *(continued)*

IV F – General symbols (see also IEC Publications 617 and 417)		
No.	Item	Symbol
F-18	Non-insulated thermocouple (thermal converter)	
F-19	Insulated thermocouple (thermal converter)	
F-23	Shunt	
F-30	Magnetic field strength expressed in kiloamperes per metre (e.g. 2 kA/m) producing a variation corresponding to the class index	$\boxed{2}$ kA/m
F-31	Earth (ground) terminal (general symbol)	 (5017)*[1]
F-32	Zero (span) adjuster	
F-33	Refer to a separate document	
F-42	Frame or chassis terminal	 (5020)*
F-43	Protective earth (ground) terminal	 (5019)*
F-44	Noiseless earth (ground) terminal	 (5018)*
F-45	Signal low terminal	
F-46	Positive terminal	+ (5005)*
F-47	Negative terminal	— (5006)*
F-48	Resistance range setting control	 (5174)
F-49	Overload protection device fitted	 (5175)
F-50	Overload protection device reset control	 (5176)

[1] Symbol F-31 is deprecated. One of the more explicit symbols, e.g. F-42, F-43, F-44 or F-45, should be used instead.

* Numbers identified by an asterisk are the reference numbers of the symbols in IEC Publication 417. The number is not part of the symbol.

9. Markings and symbols for terminals

9.1 *Requirements for markings*

The markings shall be applied on, or adjacent to, the relevant terminal.

If there is insufficient space adjacent to a terminal for the marking specified, a permanently attached name-plate shall be provided giving details of the terminals and identifying them in an unambiguous way.

The markings shall be indelible, remain legible and be of a colour which contrasts with the background, or shall be moulded.

A marking shall not be applied to a removable part of a terminal.

If markings are applied to a cover over several terminals, it shall not be possible to fit the cover so that the markings may be misinterpreted.

When a diagram of connections is supplied, the marking for a terminal shall be identical to that on the diagram of connections relating to that terminal.

9.2 *Earthing (grounding) terminals*

Terminals which are required to be connected to a protective earth (ground) for reasons of safety shall be marked with Symbol F-43 (Table IV F).

Terminals which are required to be connected to a noiseless earth (ground) to prevent impairment of performance shall be marked with Symbol F-44 (Table IV F).

Terminals which are connected to accessible conductive material but which are not necessarily required to be connected to earth (ground) shall be marked with Symbol F-42 (Table IV F).

9.3 *Measuring circuit terminals*

If a terminal of a measuring circuit is intended to be kept at or near to earth (ground) potential (e.g. for safety or functional reasons), it shall either be marked with a capital N if it is intended to be connected to the neutral conductor of an a.c. supply circuit, or be marked with Symbol F-45 (Table IV F) in all other circumstances.

These markings are additional to, and shall follow, any other markings prescribed for the relevant terminal.

APPENDIX A

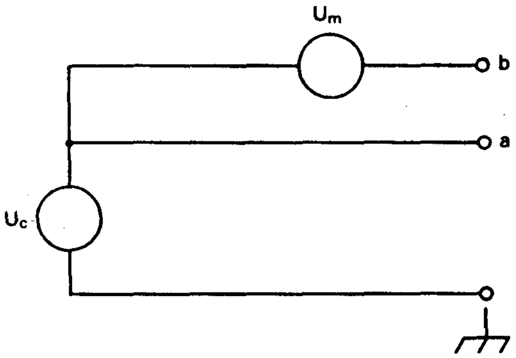
DETERMINATION OF THE INFLUENCE OF PARASITIC VOLTAGES

Connection of earth (ground) and screen, if any, and the unused inputs shall be in accordance with the manufacturer's instructions.

Figures A1 and A2 are examples only.

A1. Common mode interference

This test is made in accordance with the circuit shown in Figure A1.

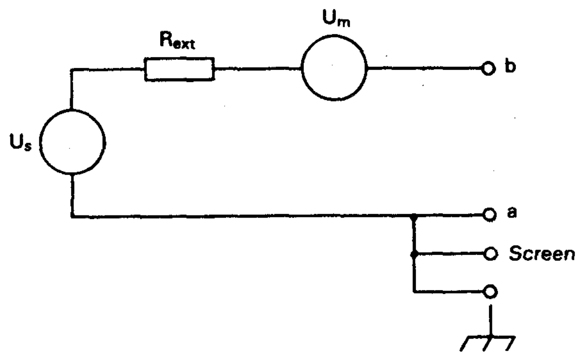


a, b - input terminals
U_c - source of parasitic voltage between measuring circuit and earth (ground)
U_m - source of measured voltage

Figure A1 - Circuit diagram for the common mode test for one axis

A2. Series mode interference

This test is made in accordance with Figure A2.



a, b = input terminals
U_s = source of series mode parasitic voltage
U_m = source of measured voltage
R_{ext} = external resistance

Figure A2 – Circuit diagram for the series mode test

A3. Statements as to the tests

It should be noted that generally four (three) distinctly different values of the parasitic voltage will be obtained for one range or a set of ranges, i.e.:

Measurand	Parasitic voltage	
	Common mode	Series mode
a.c.	a.c. and d.c.	d.c.
d.c.	a.c. and d.c.	a.c. at mains frequency a.c. at twice mains frequency

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AMENDMENT 1

Page 9

2.9.1 *Accuracy*

Replace the second paragraph of this subclause by the following:

For an accessory, the closeness of the marked value to the conventional true value.

Page 13

4.3 *Conditions for the determination of intrinsic error*

Replace, page 14, *the first paragraph by the following:*

The recorded value of the measurand is read from the chart. If the value is read from chart lines, an appropriate correction shall be made to take account of the accuracy of the distance apart of the chart lines.

Page 14

4.4.1 *Limits of the dead band*

Replace the title and text of this subclause by the following:

4.4.1 *Maximum value of the dead band*

Under reference conditions, the dead band is included within the intrinsic error.

The dead band may exceed the value corresponding to the permissible error when one (and only one) influence quantity is within its nominal range of use, all the other influence quantities being at their reference values or within their reference ranges. This increase in the value of the dead band shall not exceed the permissible variation for that influence quantity.

Page 15

Subclause 5.1.2.1

Replace this subclause by the following

5.1.2.1 For values of the nominal range of use beyond the reference range (or reference value), the variation shall not exceed the values given in Table II.

Page 19

7.2 *Preferred values for sensitivity*

Replace the second line by the following:

value of measurand/millimetre

Page 21

Subclause 8.3.5

Replace column 1 in Table III by:

Example	
25 °C	
20 ····· 25 ····· 30 °C	
15 ····· 20 ····· 25 ····· 30 °C	
20 ····· 20 ····· 25 ···· 30 °C	

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